

WHAT IS CLAIMED IS:

1. An exhaust gas purifying device for an engine, comprising:

a NOx trap catalyst disposed in an exhaust gas passage of the engine including a NOx trap material to absorb NOx while oxygen of an exhaust gas is in high concentration and release the absorbed NOx while oxygen is in low concentration, a catalytic metal to purify the NOx released from said NOx trap material, and an O₂ storage material to absorb O₂ while oxygen of the exhaust gas is in high concentration and release the absorbed O₂ while oxygen is in low concentration;

a NOx sensor disposed in the exhaust gas passage downstream of said NOx trap catalyst;

NOx absorbed amount calculating means for calculating the amount of NOx absorbed in said NOx trap catalyst;

NOx release controlling means for lowering the concentration of oxygen of the exhaust gas in the exhaust gas passage so as to cause said NOx trap catalyst to release NOx absorbed when the amount of the NOx absorbed in said NOx trap catalyst reaches a specified amount;

operating condition detecting means for detecting an operating condition of the engine;

determining means for determining whether a specified diagnosis condition to diagnose said NOx trap catalyst is satisfied or not, according to the engine operating condition detected by said operating condition detecting means;

detecting means for detecting whether or not O₂ release from said O₂ storage material caused by oxygen concentration lowering of the exhaust gas in the exhaust gas passage by said NOx release controlling means has terminated;

diagnosing means for diagnosing a degree of deterioration of respective capacities of said O₂ storage material and said catalytic metal that are included in said NOx trap

• catalyst when said specified diagnosis condition is satisfied, said diagnosing means
• diagnosing a degree of deterioration of O₂ storage capacity of said O₂ storage material according to output values of said NO_x sensor that are generated during a term from the beginning of the oxygen concentration lowering of said NO_x release controlling means until a termination of the O₂ release from said O₂ storage material, said diagnosing means diagnosing a degree of deterioration of NO_x reduction capacity of said catalytic metal according to an output value of said NO_x sensor that is generated after the termination of the O₂ release from said O₂ storage material,

wherein said NO_x release controlling means is configured such that a speed of lowering oxygen concentration thereby when said specified diagnosis condition is satisfied is slower than that when said specified diagnosis condition is not satisfied.

2. The exhaust gas purifying device of an engine of claim 1, wherein said detecting means comprise an O₂ sensor disposed in the exhaust gas passage downstream of said NO_x trap catalyst, and O₂ release termination determining means for determining that the O₂ release from said O₂ storage material has terminated when an output value of said O₂ sensor indicates a value equivalent to a stoichiometric air-fuel ratio of the exhaust gas.

3. The exhaust gas purifying device of an engine of claim 1, wherein said diagnosing means is configured so as to diagnose that O₂ storage capacity of said O₂ storage material included in said NO_x trap catalyst has deteriorated when an integrated value of output values of said NO_x sensor with respect to time during a term from the beginning of the oxygen concentration lowering of said NO_x release controlling means until a termination of the O₂ release from said O₂ storage material is smaller than a first threshold value.

4. The exhaust gas purifying device of an engine of claim 1, wherein said diagnosing means is configured so as to diagnose that O₂ storage capacity of said O₂ storage material included in said NO_x trap catalyst has deteriorated when a value that is gained by dividing a difference between a maximum value and a minimum value of output

values of said NOx sensor that are generated during a term from the beginning of the oxygen concentration lowering of said NOx release controlling means until a termination of the O2 release from said O2 storage material, by the time spent during said term is greater than a second threshold value.

5. The exhaust gas purifying device of an engine of claim 3, further comprising first correcting means for correcting said first threshold value, in such a way that the greater a difference between the amount of absorbed NOx calculated by said NOx absorbed amount calculating means and said specified amount is, the greater value said first threshold value for diagnosing the deterioration of O2 storage capacity of said O2 storage material included in said NOx trap catalyst is corrected to.

6. The exhaust gas purifying device of an engine of claim 4, further comprising second correcting means for correcting said second threshold value, in such a way that the greater a difference between the amount of absorbed NOx calculated by said NOx absorbed amount calculating means and said specified amount is, the smaller value said second threshold value for diagnosing the deterioration of O2 storage capacity of said O2 storage material included in said NOx trap catalyst is corrected to.

7. The exhaust gas purifying device of an engine of claim 1, wherein said diagnosing means is configured so as to diagnose that NOx reduction capacity of said catalytic metal included in said NOx trap catalyst has deteriorated when a maximum value of output values of said NOx sensor that are generated after a termination of the O2 release from said O2 storage material is greater than a third threshold value.

8. The exhaust gas purifying device of an engine of claim 1, wherein said diagnosing means is configured so as to diagnose that NOx reduction capacity of said catalytic metal included in said NOx trap catalyst has deteriorated when an integrated value of output values of said NOx sensor with respect to time during a term from a termination of the O2 release from said O2 storage material until a specified time has passed since the termination of the O2 release is greater than a fourth threshold value.

9. The exhaust gas purifying device of an engine of claim 1, wherein said diagnosing means is configured so as to diagnose that NOx reduction capacity of said catalytic metal included in said NOx trap catalyst has deteriorated when a value that is gained by dividing a difference between a maximum value of output values of said NOx sensor that are generated during a term from a termination of the O2 release from said O2 storage material until a specified time has passed since the termination of the O2 release and an output value of said NOx sensor that is generated at the time when the O2 release from said O2 storage material has terminated, by a difference between the output value of said NOx sensor that is generated at the time when the O2 release from said O2 storage material has terminated and an output value of said NOx sensor that is generated at the time when said specified time has passed is greater than a fifth threshold value.

10. The exhaust gas purifying device of an engine of claim 8, wherein said diagnosing means further comprising second correcting means for correcting said fourth threshold value, in such a way that the greater a difference between the amount of absorbed NOx calculated by said NOx absorbed amount calculating means and said specified amount is, the greater value said fourth threshold values is corrected to.

11. The exhaust gas purifying device of an engine of claim 1, further comprising NOx trap capacity diagnosing means for diagnosing that NOx trap capacity of said NOx trap material included in said NOx trap catalyst has deteriorated when the sum of an integrated value of output values of said NOx sensor with respect to time during a term from the beginning of the oxygen concentration lowering of said NOx release controlling means until a termination of the O2 release from said O2 storage material and an integrated value of output values of said NOx sensor with respect to time during a term from the termination of the O2 release from said O2 storage material until a specified time has passed since the termination of the O2 release is smaller than a sixth threshold value.

12. The exhaust gas purifying device of an engine of claim 1, further comprising specified-amount correcting means for correcting said specified amount of NOx absorbed

amount that is used by said NOx release controlling means in executing the NOx release to a smaller value when it is diagnosed that NOx reduction capacity of said catalytic metal included in said NOx trap catalyst has deteriorated.

13. The exhaust gas purifying device of an engine of claim 1, further comprising oxygen concentration correcting means for setting the concentration of oxygen of the exhaust gas in the exhaust gas passage, which is lowered by said NOx release controlling means, to a higher value when it is diagnosed that O2 storage capacity of said O2 storage material included in said NOx trap catalyst has deteriorated.

14. The exhaust gas purifying device of an engine of claim 1, further comprising second diagnosing means for diagnosing that O2 storage capacity of said O2 storage material has deteriorated when the time spent from the beginning of the oxygen concentration lowering of said NOx release controlling means until a termination of the O2 release from said O2 storage material is shorter than a specified time.

15. The exhaust gas purifying device of an engine of claim 14, wherein said second diagnosing means further comprising third correcting means for correcting said specified time to be used for diagnosing O2 storage capacity of said NOx trap catalyst, in such a way that the greater a difference between the amount of absorbed NOx calculated by said NOx absorbed amount calculating means and said specified amount is, the longer value said specified time is corrected to.

16. An exhaust gas purifying device for an engine, comprising:

a NOx trap catalyst disposed in an exhaust gas passage of the engine including a NOx trap material to absorb NOx while oxygen of an exhaust gas is in high concentration and release the absorbed NOx while oxygen is in low concentration, a catalytic metal to purify the NOx released from said NOx trap material, and an O2 storage material to absorb O2 while oxygen of the exhaust gas is in high concentration and release the absorbed O2 while oxygen is in low concentration;

a NOx sensor disposed in the exhaust gas passage downstream of said NOx trap

catalyst;

an O₂ sensor disposed in the exhaust gas passage downstream of said NO_x trap

catalyst;

an engine speed sensor operative to detect an engine speed;

an accelerator opening sensor operative to detect an opening of an accelerator;

an engine coolant temperature sensor operative to detect a temperature of an engine coolant;

a control unit operative to receive output values of said respective sensors, and to control a fuel injector and an ignition timing of the engine and execute a diagnosis of deterioration of said NO_x trap catalyst, according to said received output values of the sensors;

wherein said control unit calculates the amount of NO_x absorbed in said NO_x trap catalyst according to an output value of said NO_x sensor; controls said fuel injector so as to lower the concentration of oxygen of the exhaust gas in the exhaust gas passage and thereby to cause said NO_x trap catalyst to release NO_x absorbed when the amount of the NO_x absorbed in said NO_x trap catalyst reaches a specified amount; determines that a specified diagnosis condition to diagnose said NO_x trap catalyst is satisfied when the engine is warmed up with the engine coolant temperature that is greater than a specified temperature and the engine is in an ordinary state with a changing rate of the accelerator opening that is lower than a specified rate; detects whether or not O₂ release from said O₂ storage material caused by oxygen concentration lowering of the exhaust gas in the exhaust gas passage has terminated according to the output value of said O₂ sensor; diagnoses, when said specified diagnosis condition is satisfied, that O₂ storage capacity of said O₂ storage material included in said NO_x trap catalyst has deteriorated according to output values of said NO_x sensor that are generated during a term from the beginning of the oxygen concentration lowering until a termination of the O₂ release from said O₂ storage material and that NO_x reduction capacity of said catalytic metal included in said NO_x trap catalyst has deteriorated

according to an output value of said NOx sensor that is generated after a termination of the O2 release from said O2 storage material; and controls the fuel injector such that a speed of lowering oxygen concentration when said specified diagnosis condition is satisfied is slower than that when said specified diagnosis condition is not satisfied.

17. An exhaust gas purifying device for an engine, comprising:

a NOx trap catalyst disposed in an exhaust gas passage of the engine including a NOx trap material to absorb NOx while oxygen of an exhaust gas is in high concentration and release the absorbed NOx while oxygen is in low concentration, a catalytic metal to purify the NOx released from said NOx trap material, and an O2 storage material to absorb O2 while oxygen of the exhaust gas is in high concentration and release the absorbed O2 while oxygen is in low concentration;

a NOx sensor disposed in the exhaust gas passage downstream of said NOx trap catalyst;

an O2 sensor disposed in the exhaust gas passage downstream of said NOx trap catalyst;

an engine speed sensor operative to detect an engine speed;

an accelerator opening sensor operative to detect an opening of an accelerator;

an engine coolant temperature sensor operative to detect a temperature of an engine coolant;

a control unit operative to receive output values of said respective sensors, and to control a fuel injector and an ignition timing of the engine and execute a diagnosis of deterioration of said NOx trap catalyst, according to said received output values of the sensors;

wherein said control unit calculates the amount of NOx absorbed in said NOx trap catalyst according to an output value of said NOx sensor; controls said fuel injector so as to lower the concentration of oxygen of the exhaust gas in the exhaust gas passage and thereby to cause said NOx trap catalyst to release NOx absorbed when the amount of the NOx

absorbed in said NOx trap catalyst reaches a specified amount; determines that a specified diagnosis condition to diagnose said NOx trap catalyst is satisfied when the engine is warmed up with the engine coolant temperature that is greater than a specified temperature and the engine is in an ordinary state with a changing rate of the accelerator opening that is lower than a specified rate; detects whether or not O2 release from said O2 storage material caused by oxygen concentration lowering of the exhaust gas in the exhaust gas passage has terminated according to the output value of said O2 sensor; diagnoses, when said specified diagnosis condition is satisfied, that O2 storage capacity of said O2 storage material included in said NOx trap catalyst has deteriorated when an integrated value of output values of said NOx sensor with respect to time during a term from the beginning of the oxygen concentration lowering until a termination of the O2 release from said O2 storage material is smaller than a first threshold value and that NOx reduction capacity of said catalytic metal included in said NOx trap catalyst has deteriorated when a maximum value of output values of said NOx sensor that are generated after a termination of the O2 release from said O2 storage material is greater than a second threshold value; and controls the fuel injector such that a speed of lowering oxygen concentration when said specified diagnosis condition is satisfied is slower than that when said specified diagnosis condition is not satisfied.